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Accuracy of the Gothenburg congestion charges forecast

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ABSTRACT

This paper explores the accuracy of the transport model forecast of the Gothenburg congestion charges, implemented in 2013. The design of the charging system implies that the path disutility cannot be computed as a sum of link attributes. The route choice model is therefore implemented as a hierarchical algorithm, applying a continuous value of travel time (VTT) distribution. The VTT distribution was estimated from stated choice (SC) data. However, based on experience of impact forecasting with a similar model and of impact outcome of congestion charges in Stockholm, the estimated VTT distribution had to be stretched to the right. We find that the forecast traffic reductions across the cordon and travel time gains were close to those observed in the peak. However, the reduction in traffic across the cordon was underpredicted off-peak. The necessity to make the adjustment indicates that the VTT inferred from SC data does not reveal the travellers' preferences, or that there are factors determining route choice other than those included in the model: travel distance, travel time and congestion charge.

1. Introduction

Transport model predictions are a cornerstone of transport appraisal, forming the fundament of welfare calculations. For congestion pricing they are an essential tool for the system design and prediction of revenues. Still, there are only a few systematic ex-post evaluations of transport model predictions (see Hartgen (2013), Nicolaisen and Driscoll (2014), and van Wee (2007) for literature reviews). One reason for the lack of systematic ex-post evaluations is that the forecast is often conducted long before the implementation of the policy or project, with the result that model inputs are inaccurate. In many cases, even the design of the project or policy has changed since the forecast was made. Another reason is lack of data describing the traffic system before and after the implementation of the policy or project.

The present paper evaluates the forecast effect of the Gothenburg congestion charges. The system is cordon-based and was implemented on 1 January, 2013. Introduction of this system provides an excellent opportunity for an ex-post evaluation, because travel times and traffic volumes were monitored in 2012 and 2013 (Börjesson and Kristoffersson, 2015). It also provides a rare possibility to evaluate the values of time assigned in the route choice model, because drivers in many OD-pairs have the choice of paying the charge or taking a detour to avoid being charged.

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A large number of studies predict the effects of proposed congestion charging schemes (e.g. Eliasson and Mattsson, 2006; Fridstrøm et al., 2000; Kickhöfer et al., 2010; Rich and Nielsen, 2007; Santos, 2002). Careful ex-post evaluations of transport model predictions, such as the present study, are important for understanding the strengths and limitations of such transport model forecasts. By drawing more general conclusions regarding which effects can be predicted with high accuracy and which effects are more difficult to model in different types of road networks, model studies can thus be interpreted in a more informed way. Moreover, comparison of the prediction accuracy of the model between the Stockholm and the Gothenburg charges indicates the extent to which the accuracy of model predictions can be generalized and transferred between cities. Studying the accuracy of transport model forecasts also helps identifying needs for model development.

Previous ex-post studies mostly deal with transport infrastructure investments. The most comprehensive one is Flyvbjerg et al. (2005), which finds large overpredictions of passenger demand for 90% of all studied rail investments: on average 106%. The authors suggest that this systematic overprediction has political causes. Pickrell (1989) finds similar results for 10 transit projects in the US. Flyvbjerg et al. find that forecasts for road investments are unbiased but still highly inaccurate: observed and predicted traffic differ more than (±) 20% for half of all studied investments. De Jong et al. (2007) show that forecasting errors tend to be caused by future scenario assumptions rather than by model errors. Now, for forecasts with long time horizons, future scenario assumptions are likely to be afflicted with uncertainty. However, the calculated impact of the investments is probably much less sensitive to uncertainly in future scenario assumptions.

Næss et al. (2006), Li and Hensher (2010) and Bain (2009, 2011) find that traffic volume on toll roads were systematically overpredicted, possibly due to optimism bias and winner's curse. Næss et al. analyse European and American projects whereas Li and Hensher analyse Australian projects. Welde and Odeck (2011) and Welde (2011), on the other hand, find that the prediction of traffic volumes on Norwegian tolled roads were fairly accurate, possibly because these forecasts and input assumptions have been scrutinized over many years. An ex-post analysis of the model predictions of the congestion charging system in London (Leape, 2006) shows that the model just slightly underpredicted the traffic reduction. Short-term prediction of charging schemes might have more accurate input variables than long-term prediction of infrastructure investments.

The effects of the Gothenburg charges were predicted by the Swedish national transport model system Sampers (Beser and Algers, 2002). Sampers has been in use for 10–15 years. It is based on state-of-practice large-scale modelling techniques, but it lacks dynamic assignment, departure time choice and activity-based modelling techniques. Sampers was also applied to forecast the effects of the Stockholm congestion charges. Eliasson et al. (2013) find that the model predictions were accurate enough to facilitate the design of an efficient system. However, travel time gains on links outside the toll cordon were substantially under-predicted, due to the inability of the static model to capture dynamic congestion and spillback queues.[2] Consequently, the model could not be applied to calculate the social benefit of the system.

The challenges facing the modellers forecasting the effect of the Gothenburg charges are slightly different from those that faced the modellers forecasting the effects of the Stockholm charge. On the one hand, dynamic congestion and spillback queues are a much smaller problem in Gothenburg. On the other hand, the topology of the transport network in Gothenburg implies a large number of OD relations where the driver has the choice between a faster charged route and an uncharged but slower route. In this respect, Gothenburg is more representative of other cities than Stockholm, where natural obstacles effectively bar most unwanted route choice effects.

Due to the many possible route choices, the predicted route choice proved to be highly sensitive to the value of travel time (VTT) assumed in traffic assignment. Moreover, a multi-passage rule was applied in Gothenburg (a driver is only charged once within an hour, even if making multiple passages across the cordon), implying that the path disutility cannot be computed as a sum of link attributes. The Gothenburg toll system thus resembles a zone-based congestion charging system such as the one in London. We demonstrate how this modelling problem was solved, using a hierarchical route choice algorithm in combination with a continuous VTT distribution. Assumptions regarding the VTT distribution in route choice have received surprisingly little attention in the literature. A likely reason is that very few, if any, congestion pricing systems significantly influencing drivers' route choice previously have been designed and evaluated. Evaluation of the predicted route choice in Gothenburg is, therefore, of general interest for the modelling of route choice effects in response to congestion charging in many cities.

The paper is organized as follows. Section 2 describes the charging system and Section 3 the transport model. Section 4 describes the modifications that were made to the transport model to be able to predict effects of the congestion charge and the results are shown in Section 5. Section 6 provides the conclusions of this study.

2. The gothenburg congestion charges

Gothenburg (Göteborg in Swedish) is the second largest city in Sweden with half a million inhabitants within the city borders and nearly a million in the metropolitan area. The city is traditionally a seaport and manufacturing city dominated by blue-collar jobs, the car manufacturing industry being one of the dominant sectors. These work places are mainly located north of the Göta river, while the central business district is located south of it. The region is further relatively sparsely populated and its planning does not support an efficient public transport system, implying a considerably lower share of public transport than in Stockholm. For commuting trips in the OD-pairs where the charges apply, the public transport market

[2] And this problem could thus not be avoided by adjusting parameters in the volume delay functions (Engelson and van Amelsfort, 2015).